

A FRAMEWORK FOR UNDERSTANDING STEM FOCUSED SCHOOLS

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Abstract

The importance of science, technology, engineering and mathematics (STEM) education continues to grow around the world. Increasingly, schools are examining ways to implement STEM into their programs and curriculum and policymakers are discussing the urgent need for greater and more effective STEM instruction to meet the growing needs of various industries. As a result, ministries and departments of education are responding by creating pathways for schools to become specialized STEM-focused schools. These schools, theoretically, would offer curriculum designed to foster critical thinking, experiential learning opportunities in STEM, and innovative problem-solving by integrating the four STEM disciplines. Students in these schools often learn through project-based learning and consider real-world applications that include opportunities for collaboration with the community. The goal of these schools is often to increase student achievement and prepare students for careers in STEM fields, especially those that come from underrepresented populations. However, STEM-focused schools often face several key challenges when it comes to implementation. These challenges include ensuring students from underrepresented populations have equal access, navigating the shifts in resource allocation which can be significant, as well as evaluating the effectiveness of the programs. However, these challenges can potentially become strengths of STEM-focused schools when guided by purposeful and intentional implementation, starting with the key structures and conditions that must be in place even before starting to make significant changes. A pre-implementation framework will ensure that all critical components are thoughtfully addressed before implementation begins. This is important in order to provide a clear roadmap for future changes, organize the process and define priorities. This presentation will review the existing literature on STEM-focused schools and propose a framework for the pre-implementation structures and practices necessary before schools start the work of transforming into equitable and effective STEM-focused institutions. This information will provide teachers, administrators, and policymakers with a research-based framework around which to make informed decisions as they move toward the successful implementation of STEM in a school-wide setting.

Keywords: *STEM, STEM education, project-based learning, school change.*

1. Introduction

STEM-focused schools are those that emphasize or are organized around science, technology, engineering or mathematics disciplines. In the United States, the number of STEM-focused schools has increased in the last two decades following multiple calls for expansion of STEM at the national level and given increasing awareness that many jobs continue to be based on advances in science and engineering (National Academies of Sciences, 2024). As early as 2011, models for STEM-focused schools (inclusive, selective and CTE), with specific criteria, in order to effectively advance STEM education were proposed (National Research Council, 2011).

As the number of schools grew, many states created specific standards for schools to officially become a STEM-focused or STEM-Designated school with criteria that often involve implementing rigorous STEM-focused curricula, developing partnerships with industry or higher education, and demonstrating a commitment to fostering critical thinking and innovation in science, technology, engineering, and mathematics. In most cases, to obtain this recognition, schools must clearly demonstrate how they meet these high standards through an extensive and rigorous review process.

For most schools, the requirements are substantial. Beginning to implement change toward becoming a STEM-focused school means having an understanding of effective STEM teaching and learning, supportive and dedicated leadership, a clear action plan for implementation, and capacity to sustain the process over time. All of this can be challenging when first beginning the process. Thus, without sufficient content and pedagogical knowledge of what integrated STEM teaching and learning should look

like (Bennett & Ruchti, 2022) or how teachers and administrators create, monitor, and track systems for implementation (Fullan, 2021) obtaining a STEM designation will be challenging. Additionally, and of equal importance, without understanding the critical prerequisite components, the structures and mindsets that allow for the first steps of implementation to be successful, schools will almost certainly meet with multiple barriers and challenges. As such, schools can benefit from a clear pre-implementation framework in order to be strategically prepared for the obstacles as well as the nature and complexity of becoming a STEM-focused school.

2. Components of STEM focused schools

Studies have identified a variety of characteristics or components of STEM schools (Grant, 2023; House et al., 2020; Peters-Burton et al., 2019). While the number and range of characteristics differ, there is general agreement some key components need to be in place. These common components focus on strong leadership, an integrated curriculum, effective teaching practices and an awareness of leveraging external partnerships to support students' college or career aspirations. Each will be briefly discussed below.

For STEM-focused schools to thrive, a supportive administrative leadership team with a clear mission and vision is essential (Wieselmann, et al., 2021). This begins with leaders who are deeply committed to inclusive STEM education and recognize the long-term benefits of a STEM-focused school. Tension, confusion, and other challenges can arise early on (Slavit et al., 2016; Lesseig et al., 2019) so administrators need to create a culture of collaboration with open communication and mutual respect that guides decision-making and implementation. Effective leaders will also recognize the need and importance for on-going professional learning opportunities especially with respect to using integrated curricular resources and adopting more inquiry-based teaching practices.

STEM-focused schools typically implement an integrated curriculum, incorporating both science and mathematics, though exact definitions vary (Lesseig et al., 2019). And while some schools rely on professionally developed curricular materials, many schools develop their own integrated STEM materials, which means the curriculum will vary in quality. In turn, this can lead to issues related to implementing effective inquiry-based teaching practices as it requires an extensive understanding of science, engineering and mathematics standards as well as the pedagogical knowledge on how best to approach integration (Bennett & Ruchti, 2022).

High functioning STEM focused schools understand the importance of attending to students' college and career aspirations. Attending to the skills needed to be successful in post-secondary college and career contexts should begin in the primary grades and be expanded upon in secondary grades (Dare et al., 2021). One important aspect in building and growing these skills comes from external STEM partnerships as they connect schools with universities, businesses, non-profits, and industry leaders who provide students with real-world STEM opportunities. Likewise, these partnerships also provide valuable insights into emerging technologies and industry trends preparing students for the dynamic demands of STEM careers (Detgen et al., 2021).

3. Pre-implementation framework

Several conceptual frameworks for STEM education (Jackson et al., 2021; Kelley & Knowles, 2016; Roehrig et al., 2021) help to define how schools might implement STEM, however, these frameworks do not address implementation practices and structures in STEM-focused schools. Other scholars address the various implementation practices or certain parts of implementation, but are not comprehensive about the process or structures that must be in place before starting implementation (e.g. Slavit, 2016; Wieselmann, 2021). While existing frameworks provide valuable guidance and insight, a significant gap remains between the general concept of "implementing STEM" and the systematic, structured approach to transitioning from a non-STEM school to a STEM-focused institution. Based on our past work in supporting schools in obtaining STEM designation, we have found the following foundational elements and prerequisites as it were, necessary before formal training, professional learning, and other curricular or instructional practices change. This pre-implementation framework clarifies the essential elements to support the intentional implementation of practices and structures that create equitable and effective STEM-focused schools. In our experiences, the absence of any one of these elements substantially jeopardizes the outcomes of the work.

To begin, school leadership needs to establish a culture and structures conducive to change. This includes deliberate attention to common beliefs within the leadership team, consistent and frequent communication around the vision for the school and purpose for change, collaboration with multiple internal and external stakeholders, and an accountability to professional learning. Each of these will be discussed in further detail below.

A clear vision for change is not only necessary, but the first element to clearly define and establish. A comprehensive vision highlighting the benefits of STEM education for students, teachers, and the broader community must be accessible and understandable to all (Grant, 2023). Within that vision and the long-term plan for achieving that vision, measures of success, and how success will be evaluated, including ensuring students from underrepresented populations have equal access should be clearly described. The leadership team should also consider other school initiatives that may not fit the new STEM education vision, and may take away from the vision as this may lead to confusion around purpose and intended outcomes. Next, the school will need to create a STEM Leadership Team, comprising teachers and administrators, to guide the development of the vision statement. They will also be the ones to ensure a phased approach to implementing changes over time.

Next, the STEM leadership team will need to engage a variety of stakeholders early in the planning process. Building relationships, as well as maintaining open and regular communications, with a variety of stakeholders is critical anytime a major initiative begins (Crotty, 2018). Parents and families are a natural group to include but the STEM leadership team should make deliberate efforts to include community leaders, industry partners, and aligned community organizations from the planning phase onward. These stakeholders bring insights and perspectives not often found within the internal school community and the leadership team should be prepared to leverage these partnerships to enhance learning opportunities, mentorship programs, and access to real-world STEM applications. Additionally, the STEM leadership team should begin hosting regular outreach and educational events, such as STEM “Open Houses” to showcase student work and STEM Family Nights to provide hands-on STEM experiences for families, fostering transparency and buy-in. This creates informal opportunities to continually educate these external stakeholders.

Simultaneously, some internal structures can be adapted or adopted to support the long-term intended change. For example, schools must create schedules to ensure teachers have sufficient common planning time, both within their subject areas and across interdisciplinary teams. Eventually, this common planning time will become proper Professional Learning Communities (DuFour et al., 2024) wherein teams can co-plan, examine data from student learning, and otherwise refine learning experiences and assessment practices. Additionally, time should be built into the schedule for regular whole-school professional learning sessions to enhance teacher expertise and promote collaboration (Ruchti et al., 2018). In time, this will lead to teacher-driven professional learning, which further builds the internal professional capacity of the teachers. Furthermore, schools should consider ways to create flexibility in the daily schedule in order to support interdisciplinary curriculum and instruction, allowing time for collaboration, exploration, and reflection. It is worth considering options such as block scheduling, interdisciplinary periods, or advisory time for collaboration and for exhibition days when students showcase their work.

Next, the STEM leadership team needs to consider the financial implications associated with the transition. This includes considering what additional STEM-aligned curricular resources will be needed and when. Likewise, the team needs to inventory their technology resources as they may need to invest in, or update, additional classroom technologies such as laptops, tablets, and interactive whiteboards or data collection probes and software. For some schools, it is worth considering whether a dedicated STEM lab or “Makerspace” is needed; each space may need to be designed and equipped for hands-on experimentation and prototyping. Lastly, the STEM leadership team needs to understand the school’s internet capacity. Will the current bandwidth and speeds support digital tools and online learning? Lastly, given the potential initial investment in resources, the STEM leadership team should have a plan for any shifts in resource allocation.

Lastly, the STEM leadership team needs to understand how they are going to assess their progress by developing and using appropriate evaluation and continuous improvement tools. To begin, they should define clear measures of success and establish data collection processes to evaluate progress; leveraging the expertise of external stakeholders, such as higher education experts or STEM consultants, is often needed. The STEM leadership team should use this data to inform ongoing adjustments and ensure continuous improvement of STEM initiatives as would be done in a professional learning community (DuFour et al., 2024). However, the team should also use multiple other measures of effectiveness outside of student achievement tests. For example, one common measure of success or goal of STEM-focused education is expanding the number of students who pursue advanced degrees and careers in STEM, in particular for women and other underrepresented groups (National Research Council, 2011). Regardless of which measures of success and instruments used to assess this success are used, the intentionality in developing these are necessary.

4. Discussion and conclusion

Although we have presented a pre-implementation framework for becoming a STEM-focused school, it is important to remember that this change involves not only curricular modifications, but also necessitates a fundamental shift in school culture and operations. One of the foundational considerations is understanding and honoring the unique characteristics of a school and its community. Each school operates within a distinct ecosystem of traditions, values, and expectations. Therefore, as schools move forward with this transformation, it must be a dynamic, adaptive process shaped by the unique contexts, histories, and relationships within each school community. Change is never a static event, but is a continuous evolution influenced by real-time interactions and negotiations among stakeholders, including faculty, staff, administrators, and the broader community. Most often, schools must respect and integrate existing traditions while simultaneously fostering innovation. Prioritizing the school's current social and cultural context ensures that implementation is meaningful and sustainable, and also allows for the evolution of practices and the incorporation of community values. By embracing this adaptive and flexible approach, schools can foster a systematic, equitable, and lasting shift toward high-quality STEM education.

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